INFLUENCE OF A CORROSIVE ENVIRONMENT AND HYDROGENATION ON METAL CREEP

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Corrosion cracking, high-temperature hydrogenation and creep are characteristic of the equipment elements of thermal and nuclear power plants that operate at high mechanical loads and temperatures and interact with chloride-containing and hydrogen-containing working environments. The substantiation of the performance of such structural elements in relation to creep is significantly complicated by the dependence of the creep rate of structural materials on many factors - temperature, mechanical stresses and working environments.

In the report, a calculation model was built to determine the durability of structural elements at high temperature creep of metal materials under the action of long-term loads and the corrosive effect of chloride-containing and hydrogen-containing environments. The energy approach previously developed by the authors is taken as a basis [1].

The creep rate was obtained to take into account the influence of chloride and hydrogen media on metal creep:

$$\frac{\partial \varepsilon_{ij}^{cr}}{\partial t} = A\sigma_{eq}^{m} 10^{n\sigma + m_1 \chi} \left(1 + \alpha_H C(t)\right),$$

where σ_{eq} – equivalent stress; $\dot{\varepsilon}_{ij}^{cr}$ – the creep strain rate of the local volume; A, n, m_1, α_H - constants that determine the resistance of steel to corrosion cracking at a given temperature; χ – percent of magnesium chloride in solution, C - hydrogen concentration.

The developed model was tested on the example of a study of U-like heat exchange pipes with an inner radius of r1 = 13.2 mm and an outer radius of r2 = 16 mm (Fig. 1.a) made of stainless steel 12X18H12T. It was assumed that the temperature of the metal of the heat exchange tubes corresponds to T = 550 °C, and the working medium acts on the inner surface of the tubes.

The results of calculations of the time until the destruction of the heat exchange tubes of superheaters of steam boilers under different pressures and the influence of corrosive environments of superheaters of steam boilers are shown in Fig. 1. b.

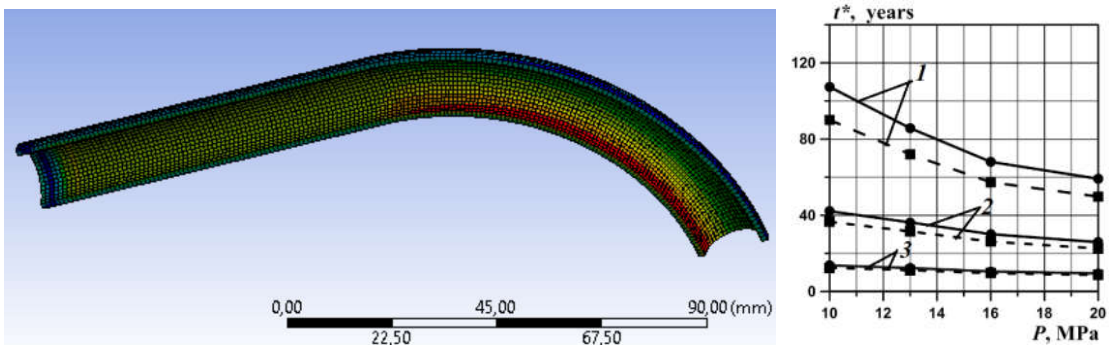

Fig. 1. The distribution of creep deformations on a fragment of a U-shaped heat exchange pipe (a) and the change in the time to failure due to internal pressure, at the place of the greatest deformation energy in the vicinity of the pipe bend without taking into account the influence of hydrogen (solid lines), and taking into account the influence of hydrogen (dashed lines); excluding (1), in 5% (2) and in 10% MgCl2 solutions (3) (b)

The obtained results are the basis for assessing the strength and reliability of structural elements, taking into account the mutual influence of various mechanisms.

1. Ya. Ivanytskyi, Ye. Kharchenko, O. Hembara, O. Chepil, Ya. Sapuzhak, N. Hembara The energy approach to the evaluation of hydrogen effect on the damage accumulation // Procedia Structural Integrity. – 2019. – 16. – P. 126–133.